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CHAPTER 6

THE RECORD/REPRODUCE SUBSYSTEM

Upon leaving the Receive Subsystem, the received signal is distributed to other subsystems for processing and/or further use. One of these subsystems is the Record/Reproduce Subsystem. This subsystem utilizes various types of recording and reproduction equipment. The specific types of equipment included in this section are magnetic tape recorders, magnetic drum recorders, recording oscilloscopes, and ink recorders.

Four basic methods of recording are involved in the operation of the subject equipment. These methods are magnetic recording, oscillographic recording, spectrographic and inked tape recording.

Magnetic recording is a method of impressing a signal on a recording medium by causing the medium to become magnetized in a pattern corresponding to the original signal. To make a magnetic recording, the medium must be a material which will become magnetized and remain magnetized for a long period of time. Modern recording materials retain their magnetism almost indefinitely. In the recording process, the material is drawn over the recording head and must receive a signal which changes in frequency, polarity, or level. The material must have the ability to become magnetized in varying amounts in small sections along its entire length. These sections are measured in microns (1 micron = 1 millionth of a meter). Materials used as recording media are wire, tape made from magnetic alloys, and tape using magnetic particles coated on paper or plastic materials. This section deals with the last type of material, magnetic particles coated on paper or plastic; the term "tape" will refer to this material only.

A direct recording oscilloscope is a device that uses a galvanometer coupled to a mirror

which deflects a light beam onto moving photosensitive paper to present a graph of amplitude versus time. (A galvanometer is an instrument that detects and converts small changes in electric current into physical motion.) The operation of the galvanometer is such that the deflection of the light beam is proportional to the signal voltage impressed on the input of the device. The time base is provided by the uniform motion of the recording paper. Usually there is a fixed light aimed at a mirror attached to the galvanometer. The reflected spot falls on the photosensitized paper. The galvanometer is caused to rotate when a voltage appears across it and this in turn deflects the mirror which swings the light beam from the rest position. For convenience and speed, an ultra-violet light is used with a pre-developed recording paper which gives an immediate trace presentation.

Almost all recording oscilloscopes are provided with some means of indicating time on the paper, such as a timing light that exposes a dot periodically. If greater accuracy is required, an external source can be utilized as an input. This is important since speed variations would render measurement along the paper ineffective.

Another method of graphic recording is the sound spectrograph. This method uses a non-photographic, current sensitive paper. The desired audio spectrum's image is "burned" into it by a current passed through a "burning" stylus.

The inked tape recording method converts radio telegraph information from the audible form to its visual equivalent on a paper tape. The written information is recorded with ink by an electrically operated recording mechanism.

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MAGNETIC TAPE RECORDERS

One of the most common types of recording/reproducing equipment in use by the Naval Security Group is the magnetic tape recorder. This device provides a rapid and convenient means of recording signals which an operator may reproduce in its original form at a later time.

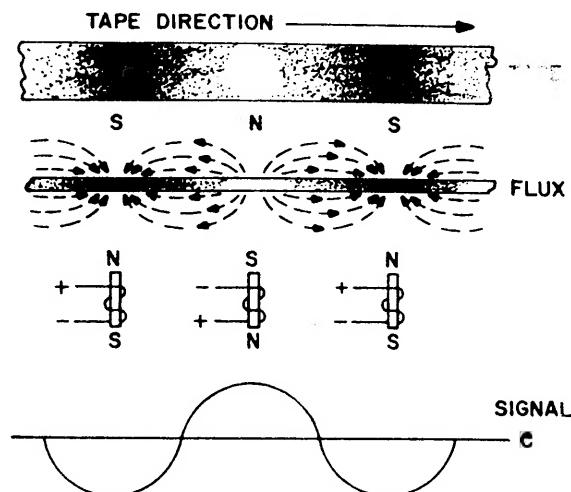
BASIC PRINCIPLES OF MAGNETIC TAPE RECORDING

There are several different types of magnetic tape recording processes in common use, each of which may require a different form of signal preprocessing or conditioning. The analog or direct recording process is the most widely used system; and the one which is discussed here. Many of the principles involved in the analog or direct recording method also apply to the other processing methods.

When material that can be magnetized is positioned near a magnetic field, the molecules of that material will rearrange themselves according to the direction of the field. There are many ways to produce a magnetic field, but in recording the most feasible way is to utilize the field produced by a current flowing through a coil of wire. This current may originate at a transducer such as a microphone which converts the mechanical energy of sound to electrical energy.

Magnetic recording tape consists of finely divided iron oxide particles deposited upon a plastic backing. During the recording process this tape is moved through a magnetic field in which the magnetizing force is alternating, and the iron oxide particles are magnetized according to the instantaneous direction and magnitude of the field. (See figure 6-1)

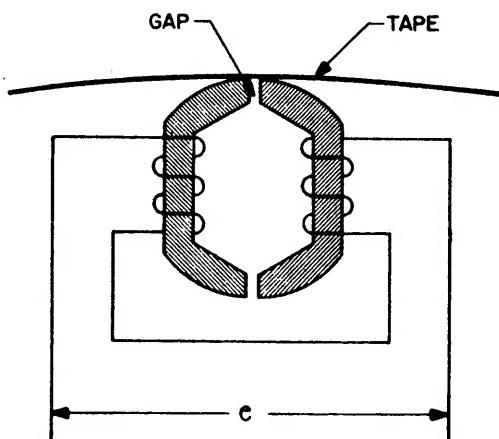
The magnetic field is produced at the gap of the recording head (essentially an electromagnet) over which the recording tape passes. This head consists of an incomplete ring of highly permeable material inserted in a coil of wire. The discontinuity in the ring forms the gap, and the ring itself is the core of the electromagnet. The recording head and its gap thus constitute a series magnetic circuit. (See figure 6-2)



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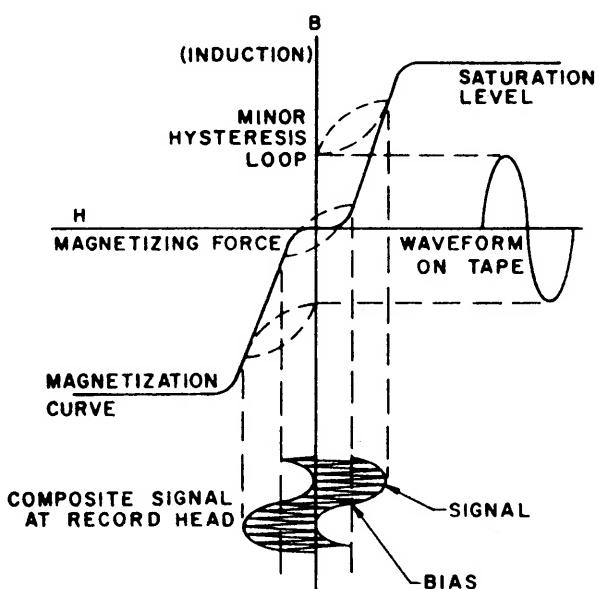
Figure 6-1.—Tape Magnetization Theory.

The magnetization curve of the iron oxide used as the recording medium is similar to that shown as the heavy line in figure 6-3. At points near the origin, the curve is extremely non-linear and without some corrective factor, the signal recorded on the tape would not be directly proportional to the signal applied to the head, thus resulting in a high degree of distortion when the tape is reproduced. This distortion is greatly reduced by mixing a high frequency,



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Figure 6-2.—Typical Recording Head.



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Figure 6-3.—Magnetization.

constant amplitude, bias signal with the signal being recorded so that linear operation is obtained. The bias signal is generally selected to be at least five times the highest frequency to be recorded.

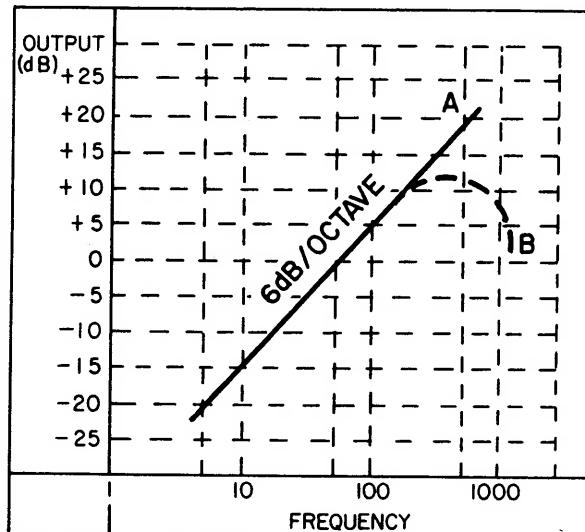
While a segment of the tape is adjacent to the recording gap, the bias causes the magnetization characteristics of the iron oxide to follow the dashed-line loops shown in figure 6-3, known as the minor hysteresis loops. As the tape leaves the gap, the influence of the magnetic field created by the bias is reduced to zero and the tape assumes a permanent state of magnetization (known as remanent induction) determined by the gap flux at that time.

After the recording process, there exists on the tape a flux pattern which is proportional in magnitude and direction to the signal recorded. If the tape is then moved past a reproduce head, which is similar in construction to the record head, the magnetic flux on the moving tape will induce a voltage in the coil of the reproduce head. This induced voltage is proportional to the number of turns of wire on the head and the rate of change of flux.

It is desirable that the gap in the reproduce head be as small as possible so it will intercept considerably less than one wave length of the signal on the tape at the highest frequency to be reproduced. However, as the gap is made smaller, the induced voltage decreases, so there is a practical limitation on decreasing the gap and still maintaining adequate signal-to-noise ratio.

The voltage across the coil increases directly as the velocity increases and wave length decreases. If the tape velocity and gap width are assumed to be constant, the output voltage from the head increases at 6 dB/octave as long as the wave length on the tape is large compared to the gap width. This results in an output-versus-frequency characteristic such as is shown in Curve A of figure 6-4. The voltage does not continue to rise indefinitely. As electrical losses in the core material increase and as the wave length on the tape approaches the same dimensions as the reproduce head gap, the actual output resembles Curve B of figure 6-4.

In order to provide an overall frequency response that is flat, an equalization circuit is inserted in one of the early stages of the reproduce amplifier. This equalizing circuit has a



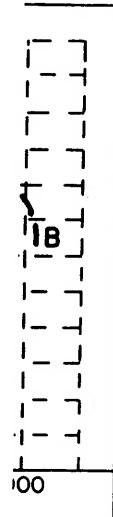
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Figure 6-4.—Output VS. Frequency.

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high-frequency droop characteristic which is inverse to the reproduce head characteristic. If plotted, the equalization curve would be complementary to Curve B in figure 6-4.

Disregarding the response of the associated amplifiers, physical aspects of maintaining constant tape speed and good head-to-tape contact, and core losses in the head, there are certain inherent properties which define the frequency limits in recording and reproducing information on a specific magnetic tape recorder-reproducer. While these properties can be varied to meet differing requirements, the overall result represents a compromise arrangement in which frequency response is primarily limited by the dimension of the reproduce head gap.

RECORDER/REPRODUCER, AN/TNH-20 (V)

The portable analog tape recorder, AN/TNH-20 (V), (shown in figures 6-5 and 6-6) is typical of the type of magnetic tape recording devices which are in wide use throughout the Naval Security Group. The AN/TNH-20 is a fully transistorized magnetic tape recorder-reproducer that is capable of recording and reproducing 4 channels of audio frequency data at 1-7/8, 3-3/4, or 7-1/2 ips. The transport is fully relay-controlled and therefore may be operated remotely. Data inputs and outputs are on terminal strips at the rear of the unit. The overall operation of the unit is described in the following discussion, followed by detailed descriptions of each major component.

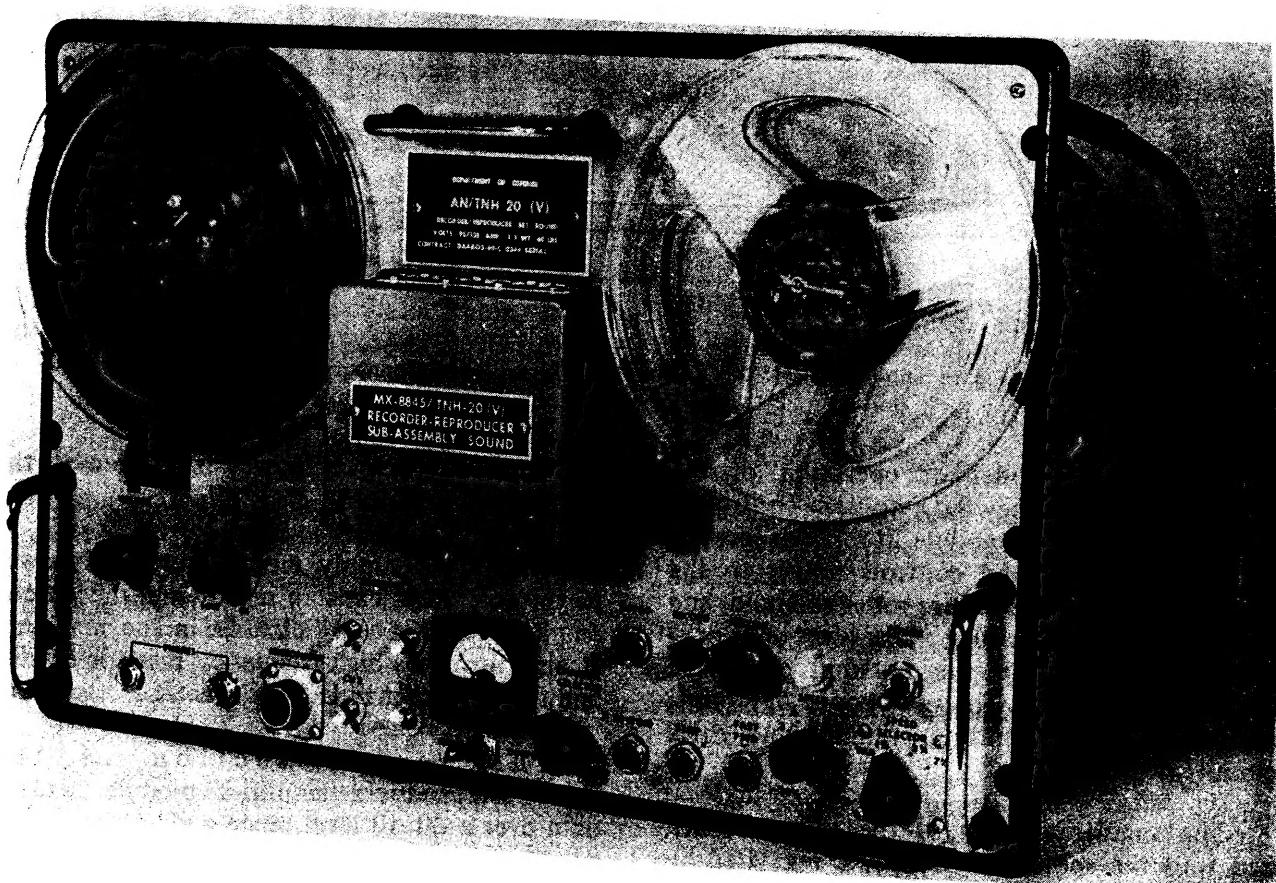
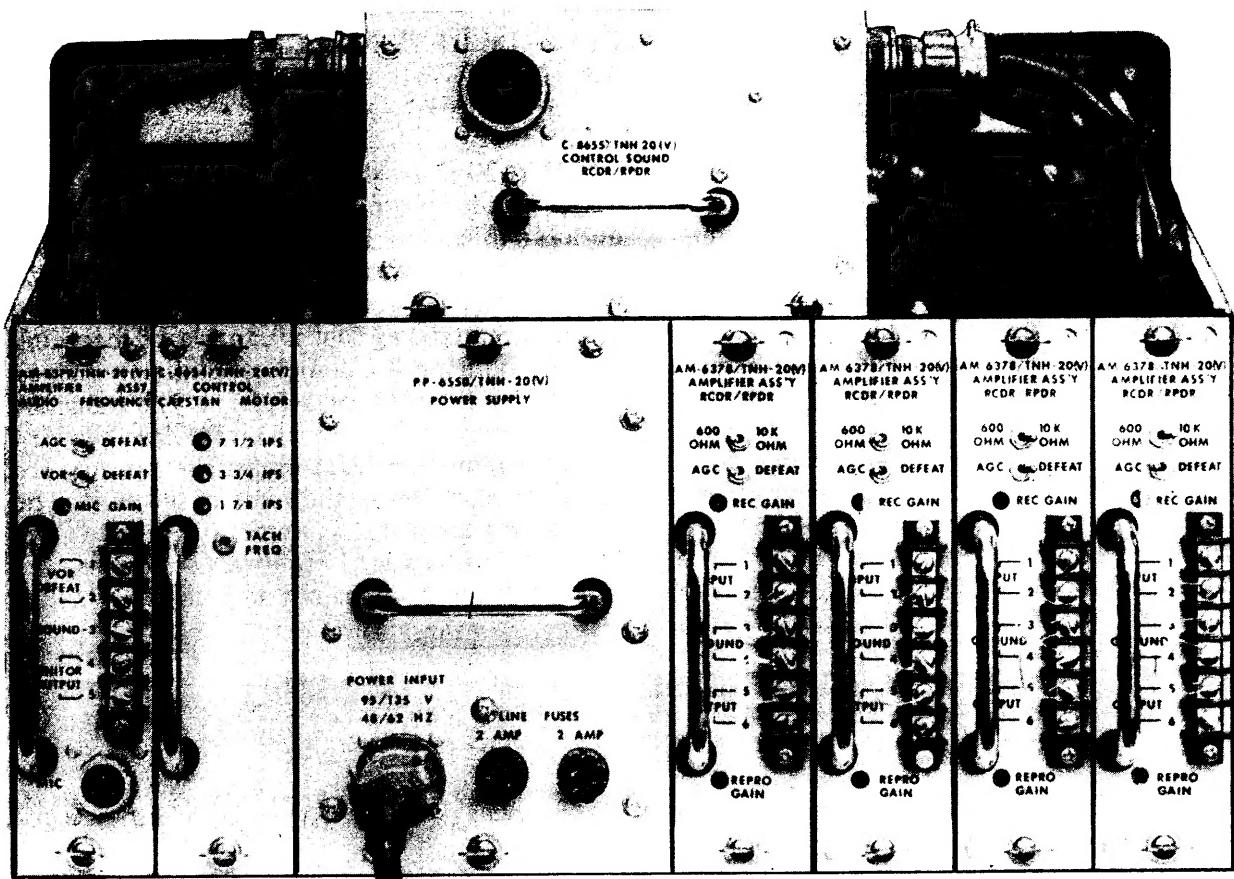


Figure 6-5.—AN/TNH-20(V), Front Panel Controls and Indicators.



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Figure 6-6.—AN/TNH-20(V), Rear Panel Controls and Connections.

The various modes of operation of the equipment (record, rewind, etc.) are controlled by the sound control module. It receives local or remote commands and controls power to the reel motors, brakes, pressure-roller solenoid, and record circuits. It has all the necessary interlocks and delays to make the possibility of tape damage very remote. The sound control module also contains the muting, timing, and drive circuitry.

The angular velocity of the capstan shaft, and thus the speed of the tape, is regulated by the capstan motor control module. The capstan may be run at 1-7/8, 3-3/4, or 7-1/2 inches per second, or it may be run at 1-7/8 ips (+50% or -30%) in the reproduce mode only. The capstan

motor runs whenever power is applied to the recorder-reproducer.

The power supply module furnishes power to the solenoids, capstan motor, and the various amplifier and control circuits in the machine. It also furnishes high-frequency bias for erasing and for the direct record process.

The record section of the recorder-reproducer amplifier module accepts data over a 20 dB level range and automatically adjusts it to a level suitable for recording when in the AGC mode. It then mixes the data with bias and applies the resulting signal to the record head. The reproduce section amplifies the low-level signal from the reproduce head,

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amplitude equalizes the signal, and feeds it to the output terminals. Both the record input and reproduce output of the recorder-reproducer amplifier are transformer coupled to allow for balanced operation.

The audio frequency amplifier contains a VU meter amplifier, a microphone amplifier, a monitor amplifier and a voice operated relay (VOR) circuit. The VU meter amplifier accepts the output of the CHANNEL SELECTOR switch and the INPUT-OUTPUT switch and drives the VU meter. The microphone amplifier accepts a low-level, low-impedance signal from a microphone, automatically adjusts the level of the signal when in the AGC mode and feeds the signal to Channel 4. The microphone amplifier input is transformer coupled. The monitor amplifier accepts inputs from any or all of the monitor control switches, mixes the inputs, and feeds the resulting signal to a tone and volume

control circuit. An amplifier then feeds two phone jacks and a transformer-coupled line output. The VOR circuit samples any or all of the record-reproduce data inputs just inside the isolation transformers. It then selects the record mode when an adjustable threshold is exceeded. The VOR circuit also triggers whenever the microphone is used. The system block diagram for the AN/TNH-20 is shown in figure 6-7.

Recorder/Reproducer Front Panel Controls

The front panel controls of an AN/TNH-20 are typical of those found on most magnetic tape recorder-reproducers. Although the controls on other recorder/reproducers may vary somewhat in their placement, appearance, and perhaps in their nomenclature, their basic function will be the same as those on the AN/TNH-20 (V). Tables 6-1 and 6-2 list the

Table 6-1.—Front Panel Operating Controls and Indicators

CONTROL/INDICATOR

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| A. POWER ON switch | Controls power to Recorder-Reproducer |
| B. POWER Indicator Lamp | Indicates when power is applied to equipment |
| C. Tape SPEED SELECTOR | Selects either 1-7/8 variable, 1-7/8, 3-3/4, or 7-1/2 ips |
| D. Variable SPEED Control (+50% or -30%) | Selects percent above or below 1-7/8 ips tape speed in Reproduce mode only |
| E. RECORD Pushbutton | Initiates Record function |
| F. RECORD Lamp | Indicates when tape transport is in Record mode |
| G. REPRO Pushbutton | Initiates Reproduce function |
| H. FAST FWD Pushbutton | Initiates Fast Forward function |
| I. STOP Pushbutton | Stops tape |

Table 6-1.—Front Panel Operating Controls and Indicators—Continued

J. REWIND Pushbutton	Initiates Rewind function
K. CHANNEL SELECTOR Switch	Selects channel to be monitored by VU meter
L. INPUT/OUTPUT Switch	Selects either Record Input or Reproduce Output to VU meter
M. VU Meter	Indicates level of Record and Reproduce Signals
N. Channel MONITOR Control Switches (4)	Selects Reproduce channels to be monitored at headphone jacks and monitor output
O. TONE Control	Adjusts frequency response at headphones and monitor output
P. VOLUME Control	Adjusts volume at headphones and monitor output
Q. Digital Counter	Counts from zero to indicate tape usage

Table 6-2.—REAR PANEL OPERATING CONTROLS

A. AGC/DEFEAT Switch	Selects manual gain control or AGC (automatic gain control) for microphone inputs
B. VOR/DEFEAT Switch	Selects or defeats VOR (voice operated relay) mode <u>Note:</u> In VOR mode, the front panel controls are overridden by the VOR circuitry.
C. MIC GAIN	Manual gain control for microphone inputs
<u>RCDR/RPDR MODULES</u>	
D. 600 OHM/10K OHM Switch	Selects either 600 or 10K Ohm input impedance
E. AGC/DEFEAT Switch	Selects manual gain control or AGC for Record signal inputs

Table 6-2.—REAR PANEL OPERATING CONTROLS—Continued**F. REC GAIN**

Adjusts Record level when AGC/DEFEAT switch is in DEFEAT position

G. REPRO GAIN

Adjusts reproduce level

front and rear panel operating controls and indicators (see figures 6-5 and 6-6). The AN/TNH-20 Recorder-Reproducer is designed to record and reproduce audio frequencies on standard 1/4-inch magnetic recording tape. Four separate channels or "tracks" are used simultaneously (see figure 6-8). All four channels are data channels with provisions for AGC (automatic gain control) and VOR (voice operated relay) operation. Channel 4 is also a voice channel. Record levels as indicated by the VU meter are automatically controlled when the AGC/DEFEAT switch is in the AGC position. In the DEFEAT position, record levels are controlled by the REC GAIN control located on the RCDR/RPDR amplifier module.

Digital Recording Process

Another technique of recording is the Digital Recording Process, which has been growing rapidly in importance as a result of the widespread application of digital computers to electronic data processing systems.

A sampling technique is used to measure a varying signal. The sampled readings are then converted into a code consisting of a series or group of binary digits. In contrast with the familiar decimal system which employs ten digits (0 through 9), the binary system employs only two digits (0 and 1); and all numbers are expressed in terms of these two digits.

Digital recording is accomplished by magnetizing the tape to saturation in either of its two possible directions (+ or -) at discreet points along its length. Thus, there is only one of two states of magnetization at any point on the recorded tape; namely, saturation in the positive direction or saturation in the negative direction.

Any of several techniques and variants may be used for recording binary digits. Four of the most representative methods are described below.

Return-to-Bias (RB).—The tape is magnetically biased to a predetermined level in one polarity, and "ones" are recorded by magnetizing the tape in the opposite polarity. After each pulse for a "one" the tape returns to the bias condition. In figure 6-9A the tape is magnetically biased in the negative direction. The digital number 0100110001 would be recorded as shown. Note that this method requires an external clocking system to read zeros.

Return-to-Zero (RZ).—In this method the tape is normally in its neutral (zero) condition. "Ones" and "Zeros" are assigned opposite polarities, and a bit or pulse is recorded for each digit, as shown in figure 6-9B. Return to the neutral state occurs after each pulse, and the system is self-clocking.

Non-Return-to-Zero (Change).—In the NRZ (C) recording, the tape is always saturated in one polarity or the other; the reversals in polarity occurring each time a change in bits occurs. Figure 6-9C shows the digital number 0100110001 in NRZ(C) notation.

Non-Return-to-Zero (Mark).—NRZ (M) differs from NRZ (C) recording in that the polarity is changed each time a "one" is recorded, as illustrated in figure 6-9D. Both the NRZ systems require external clockings. The NRZ (M) is the most widely used in digital recording systems, and appears to offer the best compromise between accuracy, simplicity, reliability, and compatibility. Notice that this system involves the least number of flux reversals, as indicated in figure 6-9.

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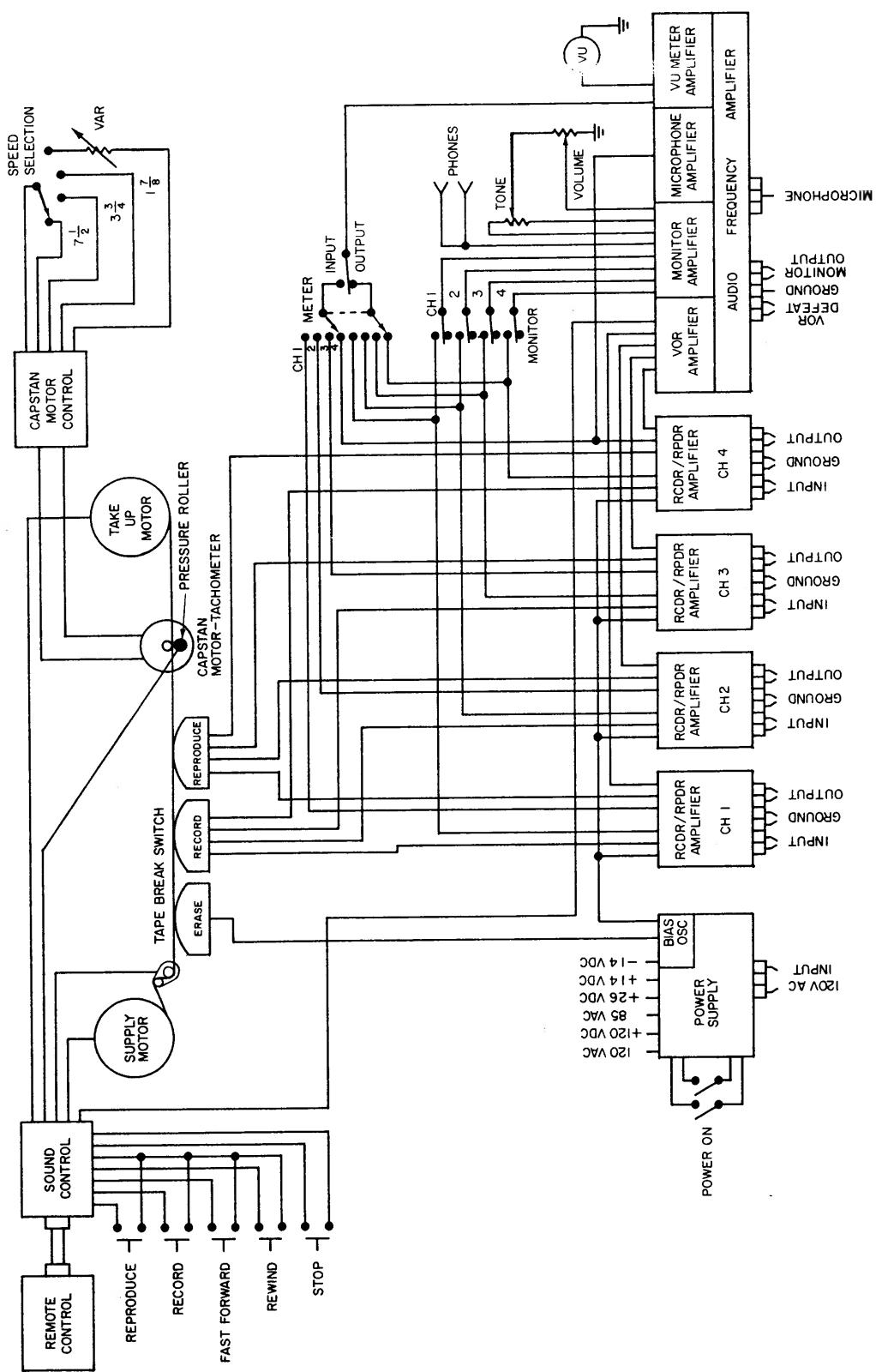
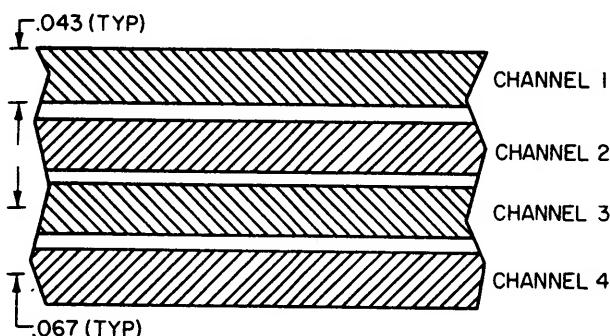


Figure 6-7.—AN/TNH-20(V), Systems Block Diagram.



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Figure 6-8.—Four Channel Magnetic Tape.

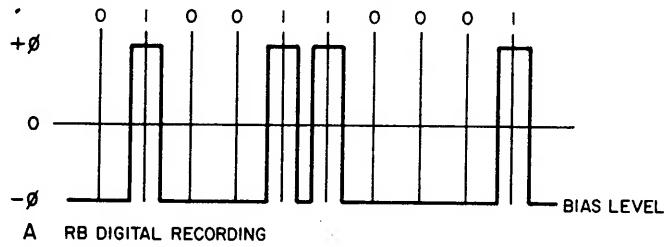
In the decimal system, any of ten different numbers (0-9) can be expressed using one digit. Using two digits 100 different numbers (0-99) can be expressed. Using n digits 10^n different numbers can be expressed. Similarly, in the digital system, two numbers, (0 and 1) can be expressed using a single digit; four possible numbers using two digits; and 2^n possible numbers using n digits. Thus, the accuracy with which a given number can be stated in digital nomenclature is limited only by the number of digits you wish to use.

This is one of the major advantages of the Digital Recording Process—It places no arbitrary limit on the accuracy of the system. We are not concerned with the dynamics range of the tape, its linearity, or the type of signal-to-noise problems encountered in the other recording processes. Here it is only necessary to properly encode the measurements in digital form and to reliably record and playback the corresponding pulses.

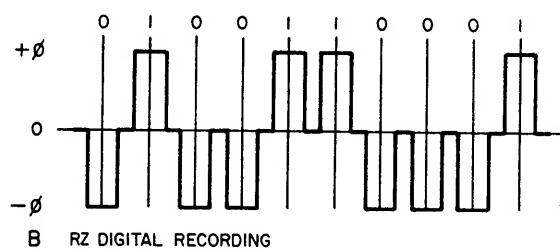
To inject a note of realism into this discussion, we must recall that these high-order accuracies have meaning only if the transducers which make the primary measurements are capable of responding with such degrees of accuracy. The data-processing system chain can be no stronger than its weakest link.

In some ways, the digital process is a simpler one than those previously discussed and presents fewer design problems. For example, the record and reproduce amplifiers can be quite elemental. The speed stability of the transport is not as important, since relatively large amounts of flutter and wow can be tolerated without effecting the recording accuracy.

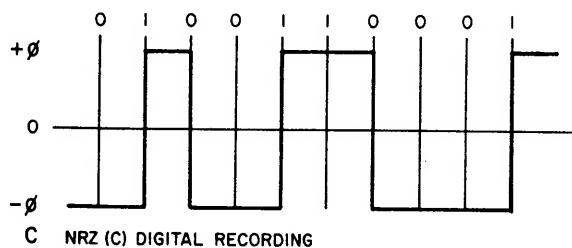
We have other problems, however, which become more important in digital recording.



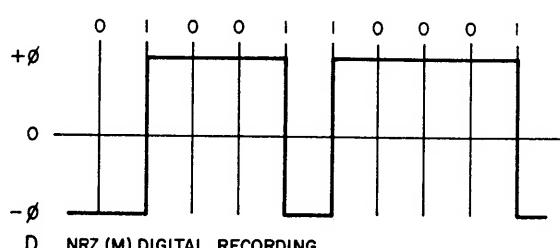
A RB DIGITAL RECORDING



B RZ DIGITAL RECORDING



C NRZ (C) DIGITAL RECORDING



D NRZ (M) DIGITAL RECORDING

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Figure 6-9.—Digital Recording Systems.

Sensitivity to tape dropout errors is the most obvious one. Since all information is contained in the presence or absence of pulses on playback, we cannot tolerate the loss of pulses or the generation of spurious pulses caused by the tape imperfections. For this reason, special precautions are taken in the manufacture, inspection, and selection of tape intended for digital recording. This does not completely solve the problem, however. Tape dropouts become most critical at short wavelengths, those approaching the size of the gap in the reproduce heads. This indicates a practical minimum duration for pulses, an obvious factor in limiting the pulse-packing density (i.e., the number of pulses per inch of tape). Present day standards permit pulse-packing as high as 1000 bits per inch for instrumentation data recording. For business data recording systems, lower pulse-packing densities are employed, generally not exceeding 300 bits per inch.

Part of this same problem is in the maintenance of excellent head-to-tape contact to minimize the dropout effect. This requires an extremely fine finish on the surface of the head, adequate tape pressure, and a minimum tendency for the head to collect oxide particles from the surface of the tape. It goes without saying that cleanliness must be maintained in the environment and handling of a digital recorder and its tape.

There are additional safeguards which are often built into the digital recording process to provide greater reliability against the possibility of tape dropouts or other errors. One of these is the use of redundancy, in which the same information is recorded twice (in whole or in part) on parallel, but separated, tracks on the tape. A second scheme is the use of a parity check; one track on the tape is reserved for a pulse which is derived from the pulses being recorded simultaneously on the other tracks. A parity pulse is of such a polarity that the sum of all bits on playback, including the parity bit, will be an odd number. Thus an error will be indicated if an odd number of pulses are lost. It will not detect two simultaneous errors. Other parity systems of greater complexity may also be used.

A problem of second greatest importance is that of tape skew. This is any tendency for the

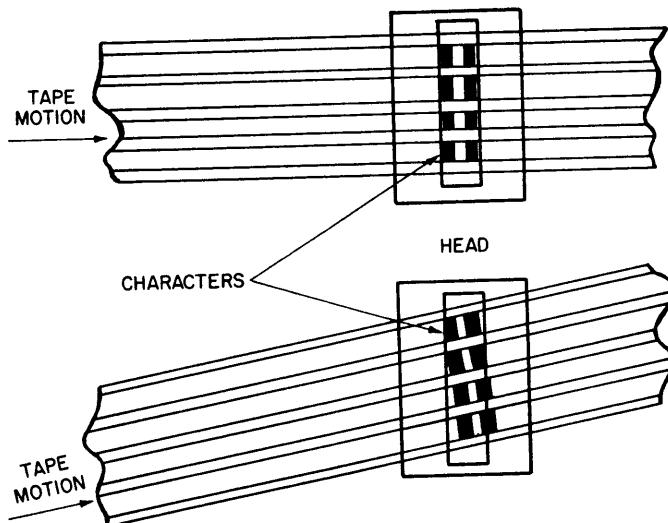
center line of the tape to depart from a perpendicular to the line of record and reproduce head gaps. The reason for this is that the digits (or bits) making up a given number or character, are usually recorded in parallel fashion, all at the same time, each on a different track of the tape.

Figure 6-10 illustrates, in exaggerated form, the effect of tape skew in which the top and bottom head tracks would be reading bits from different characters at any given instant, instead of reading all the bits from a single character at one time. The preventive measure is to maintain excellent tape guiding in the design of the transport.

Skew is perhaps the most important single factor in pulse-packing density, since the closer the pulses are packed together, the more important will become the possibility of errors due to tape skew.

Digital Magnetic Tape Recorder, RD-289

The RD-289 Digital Magnetic Tape Recorder (figure 6-11) is primarily used to record formatted data from AN/GSQ-76 (TEBO) and FLEXSCOP positions in digital form. The data is written in IBM 729 format on the magnetic



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Figure 6-10.—Error Caused By Tape skew.



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Figure 6-11.—Digital Magnetic Tape Recorder, RD-289.

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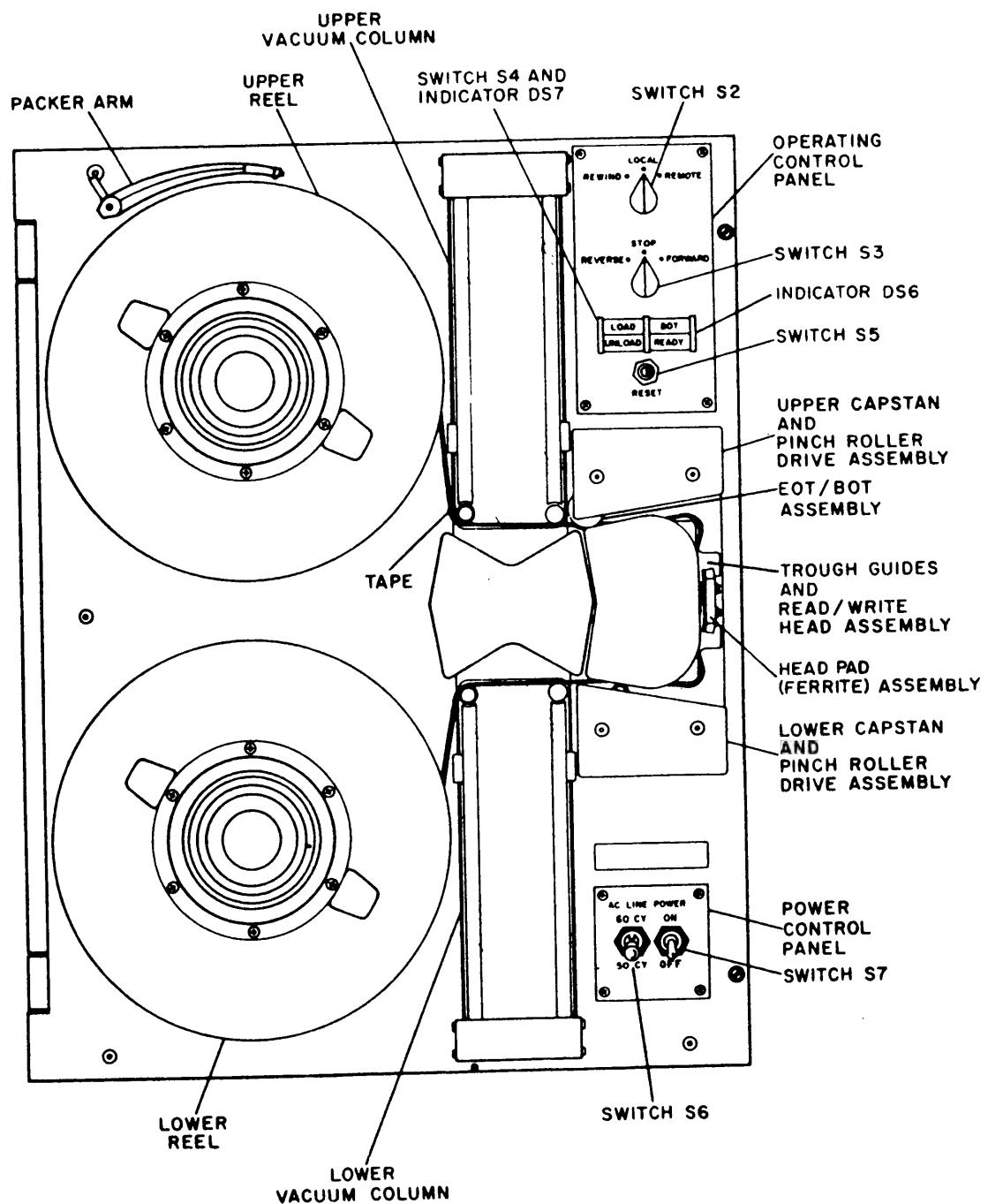
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tape as frames which consist of six data bits and one odd parity bit (the total bits in each frame are equal to an odd number). The actual recording is not continuous. Data is stored in the memory unit of the AN/GSQ-76 or FLEXSCOP system until 1024 bits of information have been obtained. Then, it is "dumped" or recorded on the magnetic tape.

The RD-289 consists of two units: The Magnetic Tape Transport, (figure 6-12) which is made up of two identical tape transports, and the Magnetic Tape Transport Control. The Magnetic Tape Transport unit contains all controls and indicators for its operation, while the Magnetic Tape Control unit contains the electronic circuits which operate the Magnetic Tape Transport.

TAPE MOVEMENT.—The tape moves (See figure 6-13) from the UPPER (payout) REEL to the LOWER (takeup) REEL for recording or playback. The constant speed capstans and the pinch rollers transport the tape. When tape movement is initiated at normal speed, either locally or remotely, the forward (lower) or reverse (upper) pinch roller presses the tape against the corresponding capstan and moves the tape by friction. Each reel is driven by a servo motor which rotates the reel for either unwinding or winding. The vacuum columns act as tape storage buffers so that constant tape tension is maintained across the read/write head. A system of photoelectric sensors control the duration and direction of the servo motor rotation, to keep the tape stored in the vacuum column in relatively constant amounts. Therefore, the amount of tape stored in the vacuum columns actually controls the starting, stopping and direction of rotation of each tape reel servo motor.

VACUUM COLUMN ASSEMBLY.—The vacuum column assembly (figure 6-14) consists of an upper and lower vacuum column mounted on a common base. The two photoelectric sensors are photoelectric cells, mounted in a rail on one side of the column. The cells operate with exciter lamps mounted in a similar rail on the opposite side. The vacuum is introduced through vacuum connector fittings at the top



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Figure 6-12.—Digital Magnetic Tape Recorder, RD-289 Line Drawing.

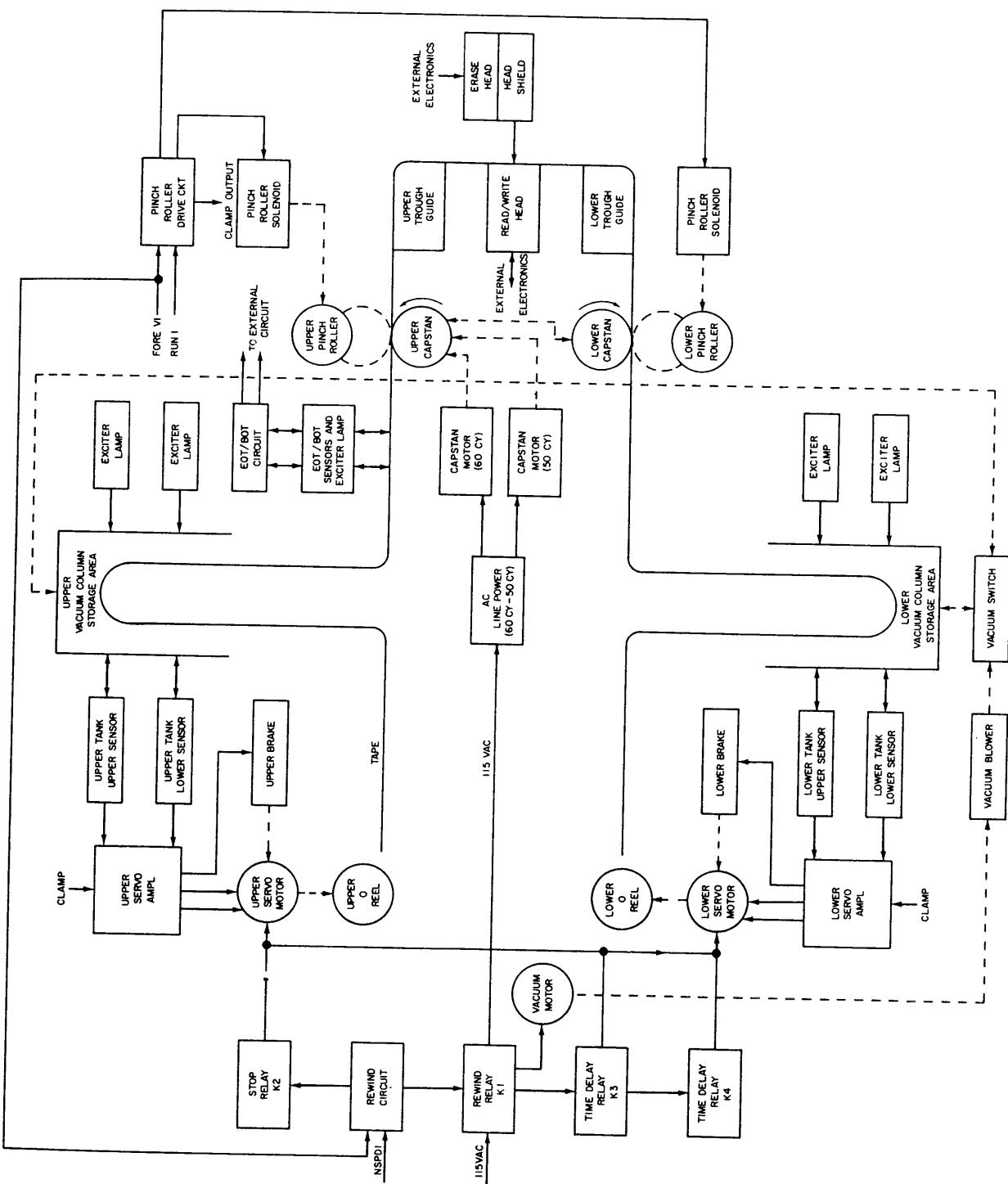
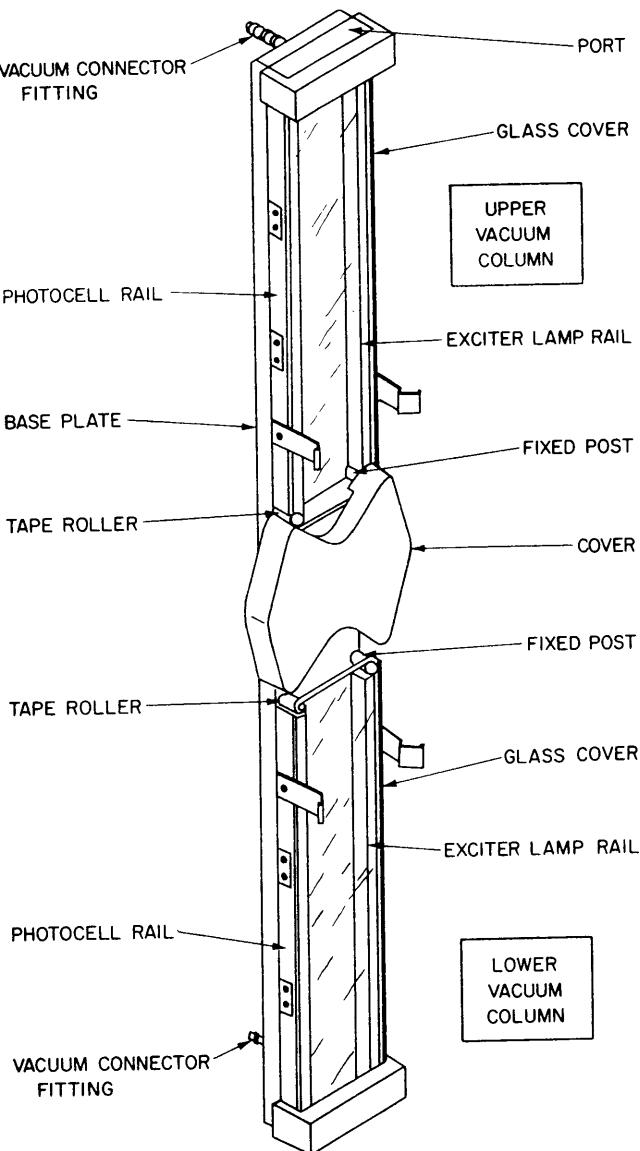


Figure 6-13.—Digital Recorder, RD-289, Simplified Block Diagram.



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Figure 6-14.—Vacuum Column Assembly of the RD-289.

and bottom of the vacuum column assembly. The vacuum columns are connected by vacuum connector fittings to a common vacuum switch. The vacuum switch acts as a sensing device to ensure that a proper vacuum exists in each column. The vacuum blower introduces a vacuum in each column which draws the tape into the columns. The tape loop formed in each

column either blocks or allows the exciter light to illuminate the associated photoelectric cell. Thus, the photoelectric sensors develop a signal which is applied to upper or lower servo amplifiers, in the control unit. The servo amplifiers energize the tape reel servo motors for either clockwise or counterclockwise rotation, or energize the tape reel servo motor brakes to inhibit tape reel rotation.

Tape rollers and fixed parts, at the opening of each vacuum column, ensure smooth tape travel through the vacuum column or across the vacuum column openings. The glass cover plate for each column is secured to the column by retaining springs on each side of the columns. A cover provided between the upper and lower vacuum columns is held in position by a spring clip.

ROLLERS AND COVERPLATES.—The tape reel servo motors are series-wound, d.c. motors, each equipped with two field windings. One field winding drives the tape reel in a clockwise direction and the other in a counterclockwise direction. Thus, tape can be reeled out or taken up from storage, in either direction. A reel brake for each motor inhibits tape reel rotation when power is removed from the motor windings. The tape reel servo motors are also used with the rewind plug-in-cord and relays K-1 through K-4 (figure 6-13) in the control unit for rewind operation.

TAPE DRIVE SYSTEM.—The tape drive system moves, guides, and stops tape during operation. Except in rewind or unload operations, the capstan motor moves the tape. A belt-and-pulley drive system connects to the upper and lower capstan. The reverse (upper) capstan rotates counterclockwise and the forward (lower) rotates clockwise. The capstans rotate constantly when the tape transport is operating, except during the rewind and unload modes. Upon receipt of a forward command, the pinch roller associated with the forward (lower) capstan is activated, and the tape is pressed against the rotating capstan. This transports tape from the upper to the lower tape reel. Conversely, during the reverse mode of

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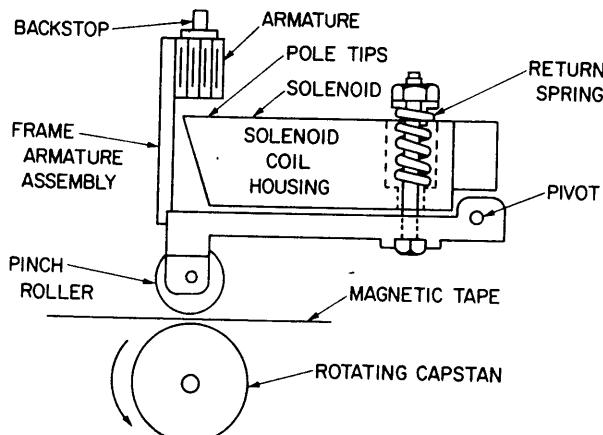
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operation, the pinch roller associated with the reverse (upper) capstan is activated, and tape is transported from the lower to the upper tape reel. The pinch roller plug-in card in the control unit controls the pinch rollers.

PINCH ROLLER SOLENOID DRIVE.—The solenoid (figure 6-15) consists of a coil housing, frame armature assembly, backstop and pinch roller, and return spring. When current is applied to the solenoid coil, the armature is attracted to the pole tips, and the entire frame assembly is pulled down toward the capstan. The tape between the pinch roller and the capstan is then driven at the speed of the capstan. When current is removed, the spring in the body of the solenoid returns the frame armature to its resting position against the backstop, and the tape stops.

CAPSTAN MOTORS.—The two capstan motors give the same speed of capstan rotation for each of the two frequencies. Motor M3 (not shown) is used when the primary line frequency is 50 cps. Motor M5 (not shown) is used when the line frequency is 60 cps. Switch S6 (see figure 6-12) connects one of the two motors to the 115V a.c. input switched in the control unit.



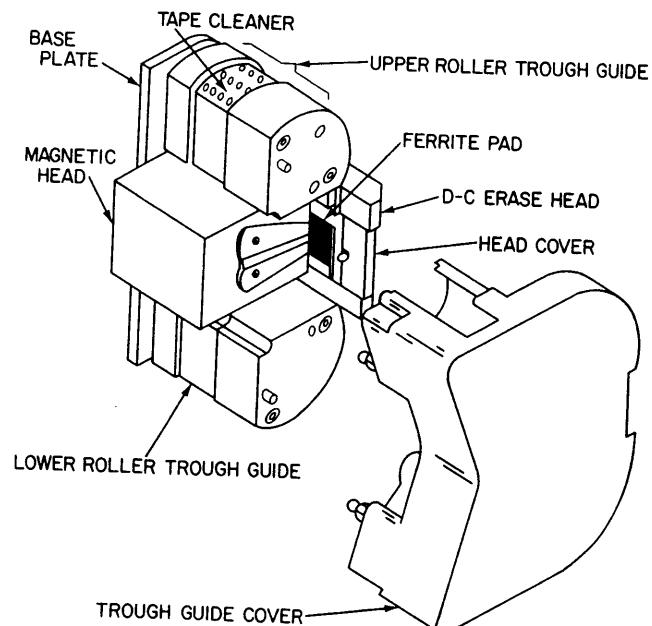
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Figure 6-15.—Pinch Roller Solenoid Drive Assembly of the RD-289.

Both motors are connected through the belt-and-pulley system to the forward and reverse capstans.

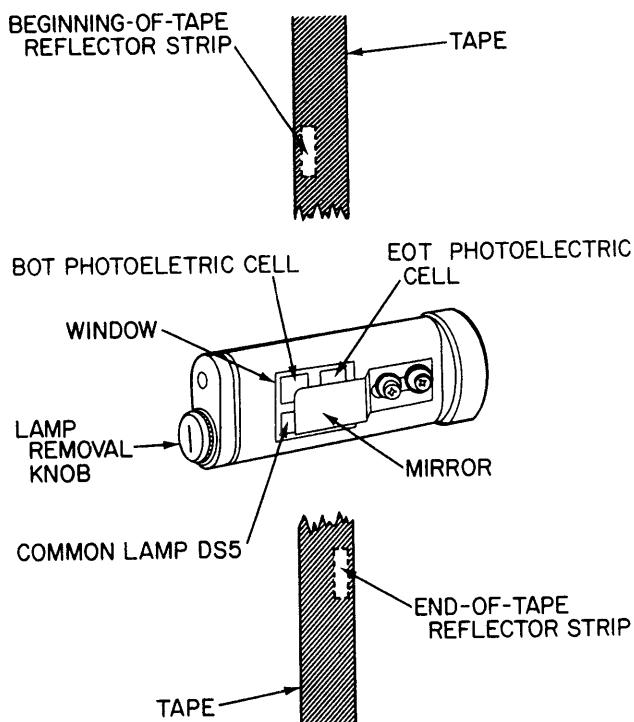
READ/WRITE HEAD ASSEMBLY.—The roller trough guides and the read/write head assembly (figure 6-16) are mounted on a common base secured to the tape transport main casting. The read/write head assembly is equipped with a head cover to which a ferrite pad is attached. This pad greatly reduces "crosstalk" between the read and write channels. In addition, the d.c. erase head is mounted on the head cover of the assembly.

E N D - O F - T A P E AND BEGINNING-O F - T A P E S E N S I N G.—The IBM compatible photoelectric end-of-tape (EOT) and the beginning-of-tape (BOT) sensor (figure 6-17) is mounted on the upper portion of the drive plate assembly before the reverse (upper) capstan. It operates with reflector strips mounted near the outer and inner edges, on the



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Figure 6-16.—Trough Guides and Read/Write Head Assembly of the RD-289.



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Figure 6-17.—End-of-Tape and Beginning-of-Tape Sensor Assembly of the RD-289.

shiny side of the tape. The BOT reflector strip is approximately 3.048 meters (10 feet) from the leading end of the tape; the EOT reflector strip is approximately 4.267 meters (14 feet) from the other end of the tape. Tape is threaded between the window and the mirror of the assembly, with the shiny side of the tape facing the window. Light from the common-exciter lamp reflects back upon the photoelectric cells which sense the EOT/BOT reflector. One cell senses the reflector strip on the inner edge of the tape (nearest the tape transport main casting) for an EOT condition. The other cell senses the reflector strip on the outer edge for a BOT condition. The light is directed constantly on the tape, and consequently each cell develops an output signal of approximately 20μ amp. The cell output signals are not sufficient to operate the EOT/BOT circuit in the control unit. However, when light is reflected from one of the reflector strips, an output of approximately 500μ amp is developed by the associated cell.

This signal enables the associated circuit, in the EOT/BOT plug-in cord, to develop an EOT/BOT signal.

TAPE BREAK SENSING.—The EOT/BOT sensor assembly also functions as a tape break sensor. The polished inner surface (facing the window) of the mirror in the EOT/BOT sensor reflects on both cells if the tape breaks. The cells then generate signals which drive the EOT/BOT circuit and produce a tape-drive-stop signal. The filament of the common exciter light is monitored so that a tape-drive-stop condition develops if the light filament opens. This action ensures that the tape transport cannot be operated with a defective EOT/BOT system.

MAGNETIC DRUM RECORDERS

Although magnetic tape recording is the most commonly seen method of magnetic recording, the magnetic drum recording process is used by NAVSECGRU for special applications. This process of magnetic recording is the same as magnetic tape recording with the exception that the magnetic drum recorder records on a wide continuous belt instead of a tape. The record/reproduce heads are maintained in a stationary position, as with magnetic tape recording, and the drum is rotated beneath the heads causing the information to be recorded on the recording belt attached to the drum.

These recording/reproducing devices use the same number of record/reproduce heads as the number of tracks the specific device was designed to handle. Some devices handle over 100 tracks simultaneously.

AUTOMATIC TAPE DEGAUSSERS

Although tape erasure by the recorder is satisfactory for some applications, it requires the tape to be run through the recorder (as in recording) and is somewhat time consuming especially when large reels of tape are involved. In addition, most precision tape recorders designed for special applications do not have an

erase capability. To erase magnetic tape quickly and efficiently, an equipment called an automatic tape degausser is available.

An automatic tape degausser (such as the one shown in figure 6-18) completely erases signals from magnetic tape by moving the whole reel of tape slowly and steadily into and out of an intense, alternating, magnetic field, while continuously rotating the reel. This subjects all portions of the tape to a thorough degaussing (erasing) action. Heavy duty coils excited by an a.c. power source provide the intense magnetic erasing field. The heavy duty coils are mounted in the rear of the degausser housing. One coil is positioned above the tape reel (when the reel is in the erasing field) and the other coil is positioned below the tape reel.

To better understand the degaussing process, consider a single magnetized particle on the

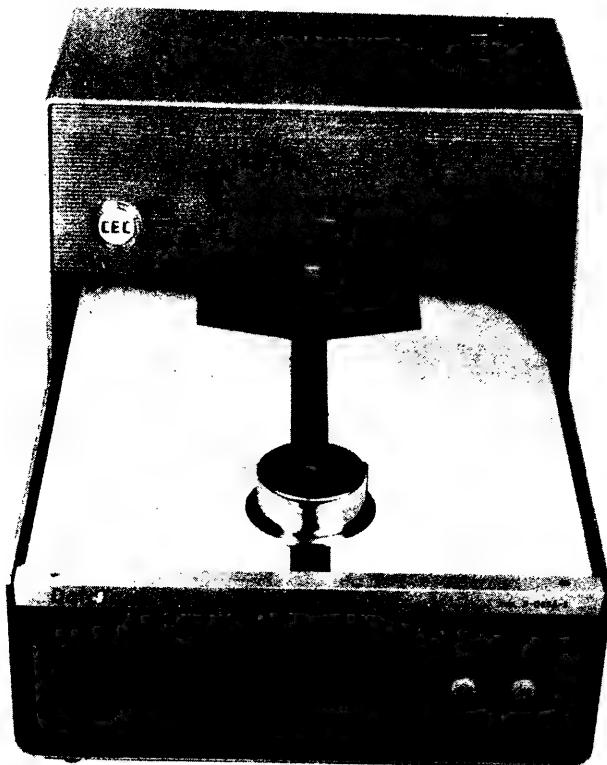


Figure 6-18.—Automatic Tape Degausser.

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tape. During the degaussing process the magnetizing force of the erasing field brings the degree of magnetization of that particle first to saturation in one polarity and then to saturation in the opposite polarity. As the tape moves out of the erasing field and the influence of the erasing field dies away gradually, the degree of magnetization of that particle continuously decreases in alternate polarities and undergoes successively smaller hysteresis loops until a state of zero magnetization is achieved and erasure is complete.

OSCILLOGRAPHS

"Visicorder" is one manufacturer's (Honeywell) trade name for a line of direct recording oscilloscopes. The Visicorder is extremely useful in applications where it is desirable to display graphically the time/amplitude relationship of several signals or of portions of one complex signal. The number of recording channels varies depending on the model, but 6, 12, and 24 channel Visicorders are common with even more channels available in other models.

Adding to the Visicorder's versatility is the range of recording speeds available. This allows a very slow-moving time base for recording recurring signals over a relatively long period, or a very fast-moving time base for "spreading out" signals of short duration.

The signal input to a Visicorder can be either "live" directly from a receiver, or as is usually the case, from a magnetic tape recording made previously. Visicorder records will remain readable indefinitely when stored away from light, and can be easily reproduced for inclusion in technical reports or for other uses.

OSCILLOGRAPH, CARL-1508

The CARL-1508 oscilloscope (figure 6-19) is a direct-recording oscilloscope which simultaneously records up to 24 channels of data on light-sensitive paper. A Galvanometer Amplifier (T6GA) amplifies weak signals to a level suitable for presentation on the Visicorder

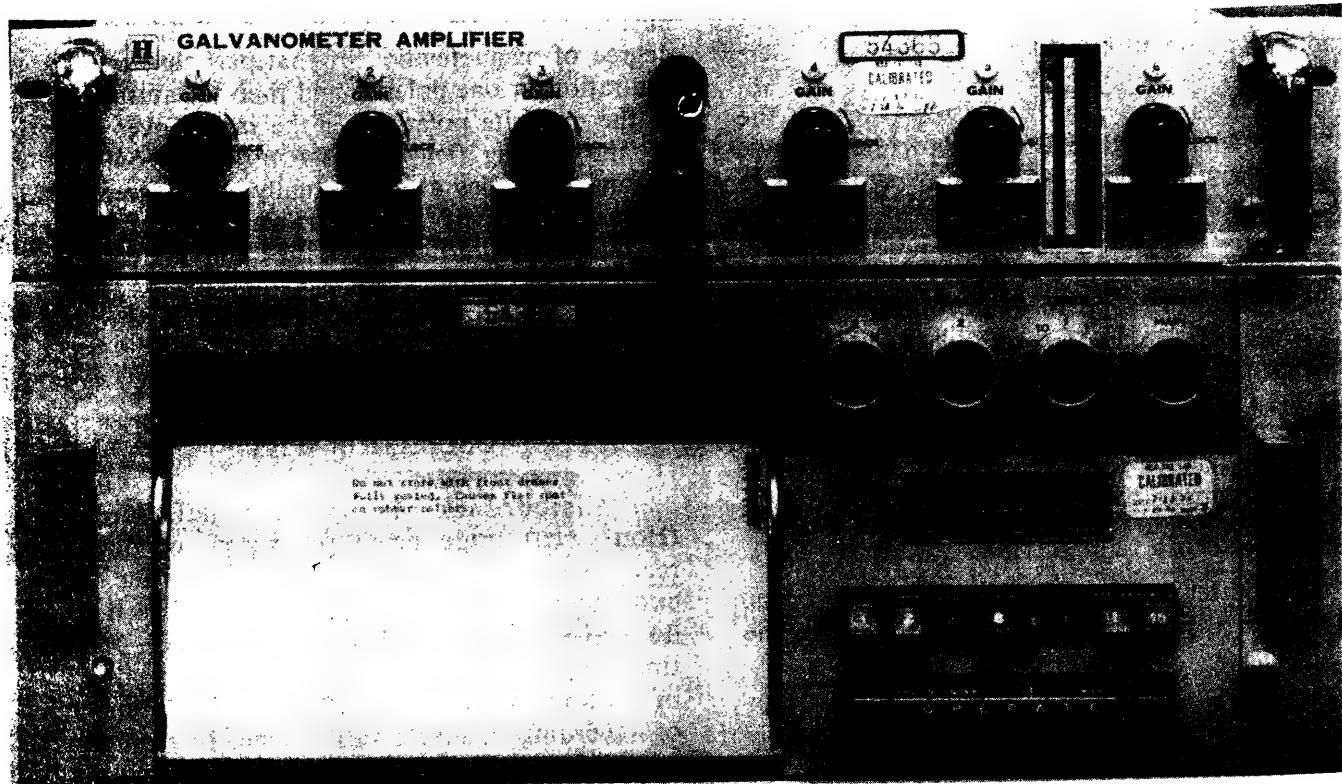


Figure 6-19.—Oscillograph, Carl-1508.

and provides individual trace amplitude controls. (A galvanometer is an instrument that detects and converts small changes in electric current into physical motion. This means that when a signal changes in amplitude, the galvanometer recognizes these changes and moves accordingly.) A mirror attached to the galvanometer causes a small reflected beam of high-intensity light to expose a portion of the light-sensitive paper giving an amplitude-versus-time presentation of the actual amplitude changes in the input signal.

The CARL-1508 Visicorder will accept either Keyed Direct Current (KDC) or Keyed Tone (KT) inputs within the frequency range of 0 to 8,000 Hz. It uses 100 foot rolls of extra thin Kodak linagraph direct-print paper and records at 12 speeds of from 0.1 to 80 inches per second. Gridlines have 0.1 inch spacing (every fifth line is darker in color.); and time lines of either 100, 10, 1.0, or 0.1 lines per

second can be selected in those instances where no external time signal is available.

SOUND SPECTROGRAPHS

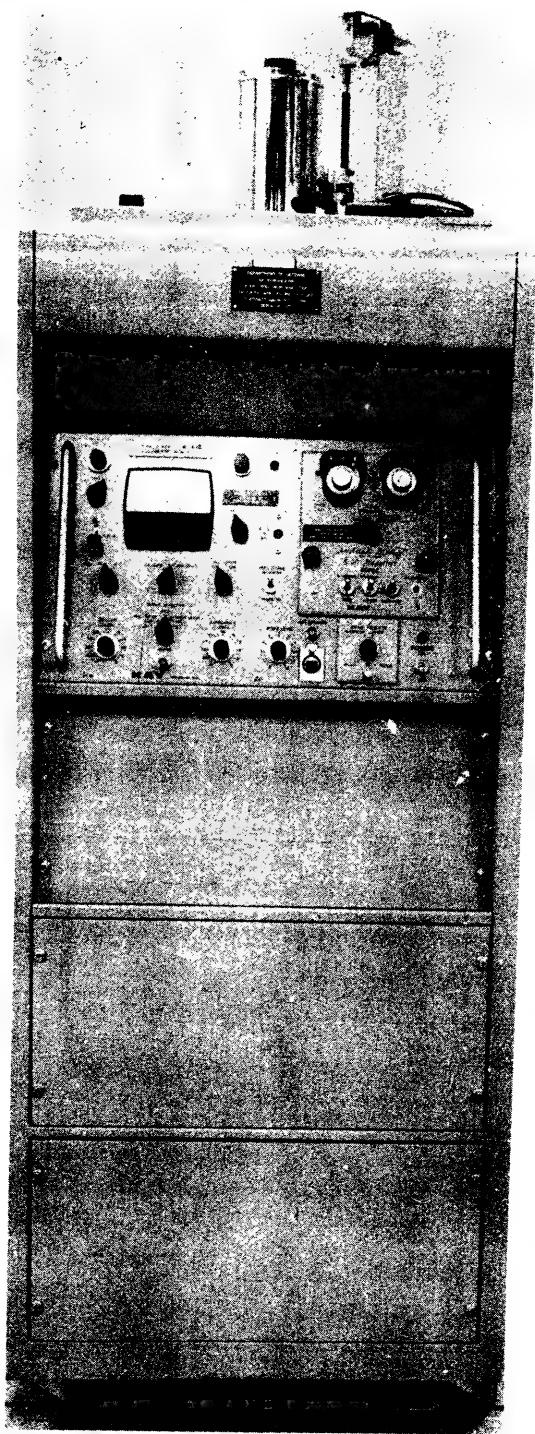
The sound spectrograph, which is commonly referred to as a sonograph, provides a means of analyzing the audio portion of a complex signal by graphically displaying the frequency and amplitude relationship of a previously recorded signal on nonphotographic, current-sensitive, recording paper. The paper is mounted on a drum which has its axis in common with a turntable. Around the periphery of the turntable is a magnetic material upon which is recorded a sample of the signal to be analyzed. This arrangement provides automatic time synchronization between the recording paper and the signal being analyzed. As the drum rotates, a playback circuit continuously feeds the sample into a heterodyne-type frequency

analyzer containing a bandpass filter and an oscillator. A high frequency current is applied to a "burning" stylus which is in contact with the paper on the rotating drum. The current is varied in amplitude in proportion to the amount of energy passed by the filter. The stylus steadily climbs on a rotating leadscrew, and as it climbs it causes the frequency of the oscillator to change. The output of this oscillator heterodynes with the input signal and the beat (difference) frequency is fed to the bandpass filter. When the beat frequency equals the bandpass frequency of the filter, current to the stylus is maximum; the instantaneous amplitude of the signal being analyzed also affects the current applied to the stylus. Because the relationship between the beat frequency and the two input frequencies remain directly proportional, the spectrograph can be calibrated so that the burned trace represents the variations in the frequency and amplitude of the signal being analyzed. Thus a time/frequency/amplitude display is obtained with time represented along the horizontal axis, frequency along the vertical axis, the relative amplitude represented by the intensity of the shading. This type of display is the primary presentation of the equipment and is called a "spectrogram".

AUDIO SPECTRUM ANALYZER (AN/GSH-23A(V) AND AN/GSH-24A(V))

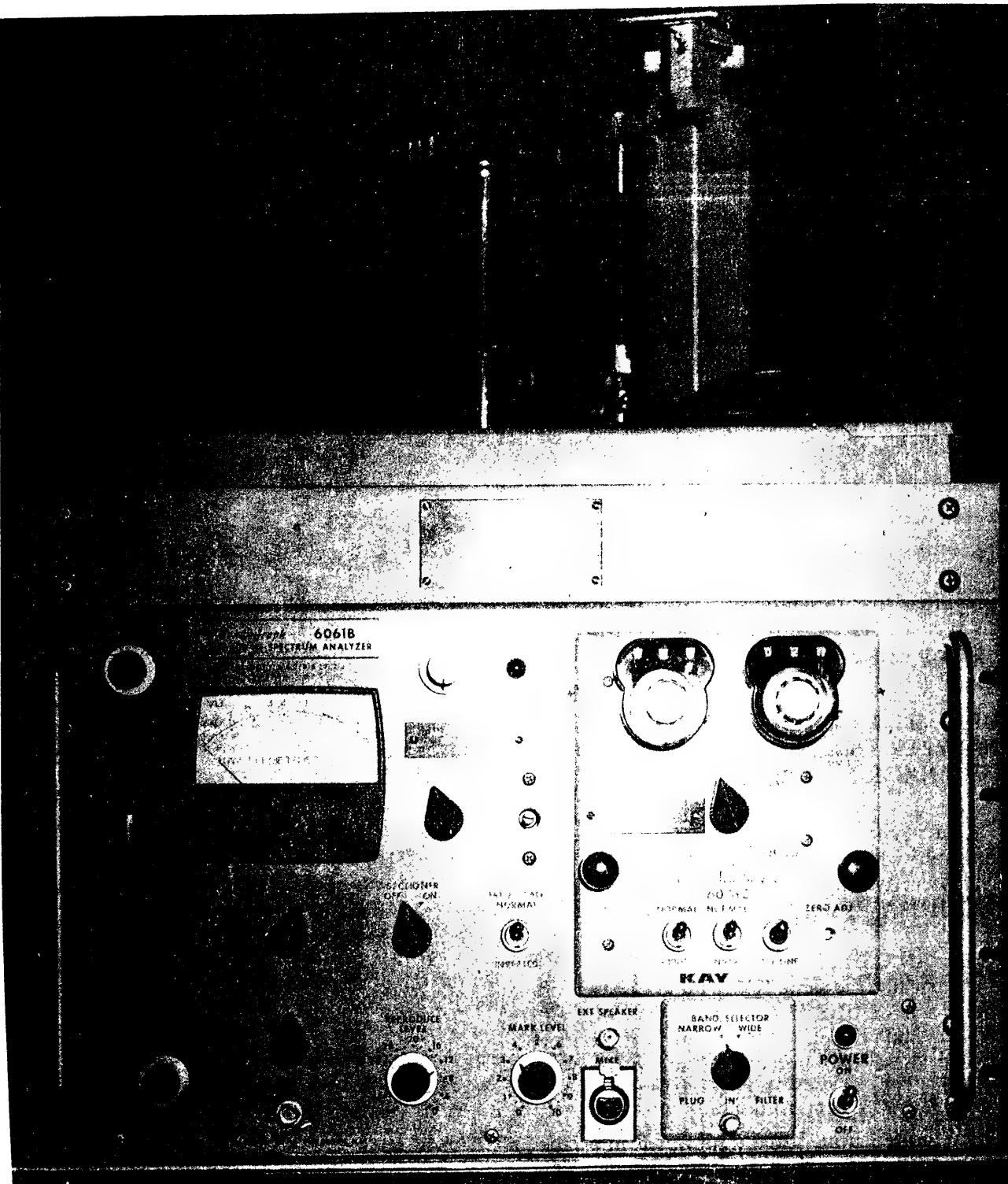
One type of sound spectrograph or sonagraph which is in common usage in the Naval Security Group at the present time is the AN/GSH-23A(V) and AN/GSH-24A(V).

The AN/GSH-23A(V) and AN/GSH-24A(V) are electrically the same type of unit. They both contain a KAY ELEMETRICS CORP.'s MODEL 6061-B Sona-Graph. The main difference between these two units is in the method of mounting. The AN/GSH-23A(V) is a portably mounted unit whereas the AN/GSH-24A(V) is a fixed mounted unit, usually mounted in a rack or bay (see figure 6-20 and 6-21). The Sona-Graph 6061-B used in these two units is an audio-frequency spectrum analyzer that produces permanent, graphic recordings of any



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Figure 6-20.—Audio Spectrum Analyzer, AN/GSH-23A(V).



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Figure 6-21.—Audio Spectrum Analyzer, AN/GSH-24A(V).

type of complex wave in the range of 85 to 16,000 Hz. Unlike conventional spectrum analyzers, the 6061-B permits three different analyses to be displayed; the operator can select the display that most accurately shows the parameters he is studying. One type display gives an overall, three dimensional picture of the signal being analyzed; frequency, amplitude and time are represented simultaneously on a single display. A second type display permits the individual intensity of each frequency component to be displayed at any preselected point in time. This type of pattern is referred to as a Section. The third analysis that can be performed is similar to an oscilloscope display; it shows the average amplitude of all frequencies present, relative to time. With this pattern, the entire input signal can be examined for flatness, resonance peaks or any amplitude study relative to time.

The audio spectrum analyzer will display any portion of audio in the 85 to 16,000 Hz range. The input signal is first recorded on a continuous ferromagnetic tape, belt, or disc; and then played back at a high speed during the analysis process. A frequency-heterodyne technique is used for the scanning system, and there are two plug-in filters available for increased flexibility. The narrow filter emphasizes frequency resolution; the wide filter emphasizes time resolution. A built-in calibration tone generator can provide frequency markers every 50, 500, or 1000 Hz along the frequency scale of the pattern, simply by depressing a switch. An adjustable AGC control can be used to extend the dynamic range of the pattern; also the darkness of the pattern can be adjusted to obtain the best contrast. For monitoring purposes, a VU meter and a speaker can be used simultaneously either when recording the input signal or when performing the analysis.

STYLUS RECORDERS

TAPE CODE RECORDER RD-112A/U

The Tape Code Recorder RD-112A/U (figure 6-22) is an undulating type ink-slip

recorder capable of converting radio telegraph code information from the normally transient, audible form to its visual equivalent in a permanently written form. The written information is recorded with ink on standard paper recording tape. An automatic tape feed feature has been provided so that during periods of automatic operation, the tape will not be drawn through the tape puller in the absence of a keying signal or with a constant carrier applied.

THE RD-112A/U is capable of recording through a continuously variable speed range of 0 to 350 words per minute.

A maintenance kit containing spare parts and special tools required for normal operational maintenance of the recorder is located on the front panel.

Basic Theory of Operation

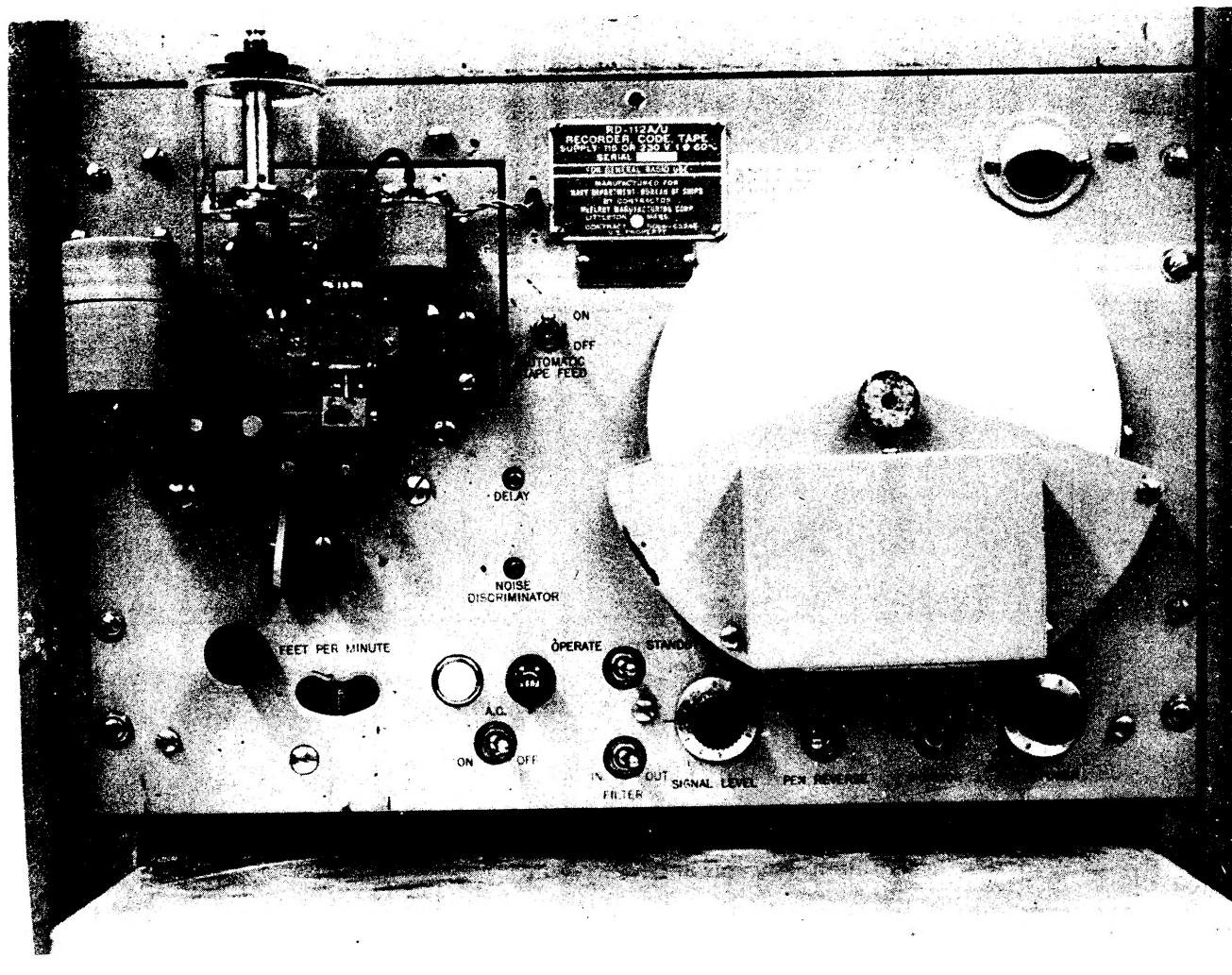
An audio signal coupled to the input of the recorder is routed through several stages of amplifying, limiting, and rectifying prior to being applied to the electro-mechanical recording mechanism. The heart of the recording mechanism consists of an armature mechanically coupled to the recording coil, operating between two powerful magnetic poles. The pen is attached to the recording coil by a connecting arm.

When the first pulse arrives, the coil, armature, and pen are driven to the limit of travel in one direction, and upon collapse of the pulse, are retained in position by the armature. The next pulse, being of opposite polarity, drives the complete assembly back to its original position where it is held firmly until another signal pulse arrives. This action causes the pen to trace an accurate reproduction of the original signal on the paper tape.

FIXED STYLUS RECORDERS

Signal Data Recorder RO-240/U

The recorder (shown in figure 6-23) is a fully transistorized and ruggedized fixed-stylus



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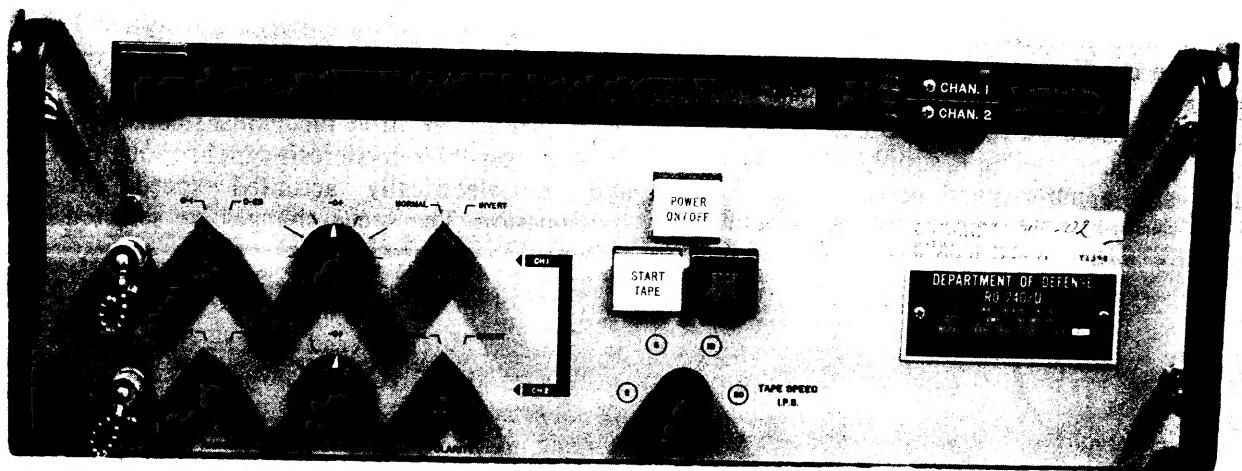
Figure 6-22.—Tape Code Recorder, RD-112A/U.

recorder that provides instantaneous direct recording of two primary channels and four auxiliary timing channels on dry electrosensitive paper. The output is in binary digital form whether the input data is of the analog or digital type. The timing inputs may be provided either by pulses occurring at externally-controlled intervals or by pulses representing numeric code.

The recorder output is printed on the tape by an array of styli. A window in the front panel of the unit permits immediate viewing of the

printed record. There are provisions to take up the tape internally or discharge it through a slot in the front panel. The tape supply consists of a 1000 foot roll of $\frac{1}{2}$ inch wide electrosensitive chart paper. When operating at a tape speed of 1 inch per second, the recorder can record continuously for 3.33 hours.

The recorder is designed to accept two channels of information-input signals and up to four channels of timing-input signals. Primary channels 1 and 2 are the information channels, and accept digital information in binary form or



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Figure 6-23.—Signal Data Recorder, RO-240/U.

analog signals that are translated into binary data by internal thresholding. Typical input signals are keyed d.c. or keyed tones from fsk demodulators. The information is fed serially into the recorder and the output is a representation of the input in either binary state "1" or "0". The timing signals are fed to timing channels No. 1 through No. 4. Timing channels No. 1 through No. 3 accept pulses having a level change from -6 volts to 0 volts. Timing channel No. 4 receives ruler time with a minimum rms value of 0.1 volts.

Six styli are active for each primary channel. One stylus is used for logic level "1" marking; another is used for logic level "0" marking; and four other styli are used exclusively to record transitions from one logic level to another. The logic levels of the outputs from the primary channels are represented by a series of dots that approximate a solid line. The dots are produced by the appropriate logic "1" or logic "0" stylus at a rate determined by the internal clock. Horizontal dot spacing is maintained essentially constant at all tape speeds by varying the pulse rate of the internal clock as a function of tape speed. Vertical dot spacing is fixed by the stylus spacing and is constant at 0.018 inch.

When a transition in the input signal level occurs, the information is stored temporarily

until the next clock pulse arrives, thus permitting recognition of transition stylus firing time. The actual printout, therefore, of the input signal level change may be delayed by up to one clock pulse.

The internal clock provides all timing control for the primary channels. Timing channels No. 1 through No. 3 are capable of receiving timing signals at a prf of 100, 10 and 1 pps. Timing channel No. 4 receives 1 kHz signals. One stylus is active for each timing channel. The stylus is activated for periods of time determined by one-shot multivibrators internal to the recorder. The one-shot multivibrator is triggered by the external timing source. The resultant display is a stylus mark of finite internally-controlled width, which occurs at externally-controlled intervals. The outputs of the four timing channels are displayed on consecutive levels below the primary channel outputs. An alternate display to the four timing channels is an alpha-numeric display of real or tape time generated originally by the AN/GSQ-53 Time Signal Set. Three of the timing styli plus two additional styli are used for marking. The information to the recorder is provided in parallel groups of five bits from the CV-1917 Time Code Translator. Readout is simultaneous over the five marking styli. A disable detector circuit is provided to detect

paper break or stoppage by detecting less than normal impedance between the styli and platen. Under these conditions the keyer (stylus driver) voltage is cut off, the transport is stopped, and a buzzer alarm sounds. The recorder transport assembly contains the tape supply and take-up assembly and a multi-speed drive system. The writing assembly consists of a modular multi-stylus writing head or transducer and a

platen. The transport assembly passes the electrosensitive paper between the styli and the platen at which time the marks are made on the paper. Associated controls are mounted on the front panel. The drive mechanism consists of a 1/24 horsepower hysteresis-synchronous motor and an electrically actuated speed change transmission. The speed changes are selected by means of magnetic clutches.

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